A Chemical and Biological Evaluation

of Three

Mine Drainage Treatment Plants

Work Document No. 47

This document has been prepared to record a specific water pollution control activity carried out, to date, in the furtherance of the water pollution control program being developed in the subject basin. The information contained herein will serve as a ready reference to aid in the planning and development of the program in the basin, for appropriate in-service training of participating personnel, and facilitating program activities with other cooperating groups.

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SUMMARY

Chemical and biological sampling was conducted at three mine drainage treatment plants operating in Washington County, Pennsylvania. These treatment plants were operated by the Jones and Laughlin Steel Corporation at their Vesta No. 4 and Vesta No. 5 Mines. Although J & L operates other mine drainage treatment plants, those selected for this evaluation were the Bercik, Kefover and Thompson facilities. Each receiving tributary was unaffected by mine drainage above the location of the treatment plant.

A fourth site was selected as a control station. This site represented an untreated effluent from an active mine which discharged to a tributary unaffected by mine drainage above the selected point of discharge. This site was located on Little Indian Creek north of Rivesville, West Virginia.

Chemical samples were collected from four areas at each of the treatment plants. These points included the receiving stream both above and below the treatment plant and the untreated mine discharge as it was pumped from the borehole as well as the treated effluent prior to discharge to the receiving stream. Biological sampling of the receiving stream was conducted above the treatment plant, immediately below the final effluent, and below the plant. Similar sampling was also conducted at the control site. Sampling was conducted once a month at each of the four sites during the months of May, June, July and August 1972.

In addition to the parameters generally associated with mine drainage, ten additional parameters were included for analysis during three of the four sampling rounds. These were all metals and included manganese, aluminum, calcium, magnesium, cadmium, chromium, copper, lead, nickel and zinc. These metals were included in a general attempt to observe the efficiency of a conventional mine drainage treatment plant for the removal or reduction of metals not commonly associated with mine drainage but often present in measurable quantities.

The effectiveness of the treatment plants in removing or reducing common mine drainage parameters was generally adequate. However, on occasion, two of these plants were responsible for the discharge of a final effluent which exhibited excessive concentrations of acidity, suspended iron and total iron.

The benthos in the receiving streams below each of the three plants were affected by the treated mine effluent. However, the adverse affects were much more noticeable.below the two plants mentioned above where both acidity and iron concentrations were occasionally excessive.

In general, the chemical and biological data rank the three plants in the same order of effectiveness when the data is evaluated from either standpoint. This order of ranking is as follows:

Kefover Treatment Plant

Thompson Treatment Plant

Bercik Treatment Plant

CONCLUSIONS

1. The Kefover Treatment Plant was the most efficient of the three plants studied. The retention time in the sedimentation pond and the dilution capacity of the receiving stream were the principal features of this facility. The flow in the receiving stream was larger than the final Kefover effluent and diluted the residual chemical constituents to a more tolerable level. The benthos in the receiving stream were only slightly affected by the treated discharge. In addition to the conventional mine drainage parameters, copper and zinc were significantly reduced at this site. A raw water aluminum concentration was completely removed by the treatment procedure on both occasions when initially present.

2. From a chemical standpoint and under normal operating conditions, the Thompson Plant was probably as effective as the Kefover Plant in removing or reducing common mine drainage parameters. However, acid slugs can be discharged from this plant during some maintenance operations. As a result, the overall treatment capability was reduced. This was particularly evident with respect to the downstream benthos. An initial raw water aluminum concentration was completely removed on each occasion it was present. Significant reductions were noted in the concentrations of nickel and zinc and to a lesser degree for several other trace metals.

3. The Bercik Plant was the least efficient of the three facilities studied. The benthic community was severely depressed immediately below the discharge point and only slightly improved well below the discharge point. The limited dilution capacity of the receiving stream below the plant was a significant factor impairing the effectiveness of this operation. A suspended iron concentration, ranging from 2 mg/l to 6 mg/l in the final effluent, was primarily responsible for the poor aesthetic appearance of the receiving stream below the facility.

4. The inclusion of trace metals in the analyses of the various mine waters were not intended as part of the overall evaluation of the treatment plants under consideration. They were included only as an additional point of interest to determine what effects conventional lime neutralization would have on initial concentrations of various trace metals in raw mine water. In reviewing the limited amount of data collected during this survey, it is apparent that the concentrations of these metals can vary significantly from discharge to discharge or with varying time periods at the same discharge point. Perhaps if a particular trace metal was consistently present in significant quantities, the treatment plant operation could be adjusted to eliminate or reduce the metal in question. Under normal operating procedures, trace metal removal appears to be a function of the chemical make-up of the mine water and the type of treatment supplied.

5. When sludge removal is necessary, it should be done frequently enough so that the retention time is consistently long enough to permit the sedimentation of nearly all suspended solids.

RECOMMENDATIONS

1. Any similar study should be conducted with an increased number of both biological and chemical samples. The sampling period should represent at least three seasons of the year. If artificial substrates are used, they should be exposed for eight weeks instead of four. The benthos, where practical, should be identified to genus. Chemical sampling should be conducted on a weekly basis rather than monthly.

2. In addition to other treatment plant construction considerations, it is recommended that consideration be given to the size of the available receiving stream. This stream should be large enough to dilute the treated effluent to a level which can be tolerated by the benthos, plankton and fish.

3. Treatment plants should be designed so that acid slugs are not released to the receiving stream when maintenance operations or equipment failures occur at the facilities. When the raw water or treated water ponds require sludge removal, a second pond should be available for temporary use during the maintenance operation.

4. The water quality of streams below new treatment plants should be comparable, to or better than, the water quality conditions exhibited in the receiving streams below the Kefover and Thompson Treatment Plants.

5. This study was not performed in a detailed manner and can only serve to grossly evaluate the three treatment plants. The chemical and biological data and related observations made during this survey can serve as an aid in planning other such studies and in designing future treatment plants.

INTRODUCTION

In September of 1971, a work activity was formulated at the Wheeling Field Office, Surveillance and Analysis Division, Region III, Environmental Protection Agency, which involved a program for updating the number of active underground coal mining operations in the Monongahela River basin. An earlier study had been conducted prior to 1965 which involved all types of mining operations both active and abandoned. Between 1965 and 1971, significant changes had occurred, particularly with respect to the number of underground mines still in operation. A resurvey of the active underground mines in the Monongahela River basin was initiated in November 1971 and was completed in December 1972. The results of this survey are published in Work Document No. 46, "The Status of Active Deep Mines in the Monongahela River Basin."

During the inventory, it was found that many of the mines, particularly in Pennsylvania, were supplying some type of treatment to their mine drainage effluent prior to discharge. Single samples collected at these treatment plants generally indicated that common mine drainage parameters were removed or reduced with a high degree of efficiency. For this reason, it was decided to conduct additional sampling at several mine drainage treatment plants in order to more accurately assess the operational efficiency of these facilities.

At the outset of the study, it was decided not to limit the survey to the collection of samples only for chemical water quality analyses. Benthic organisms are frequently used in water pollution surveys as water quality indicators because they are relatively stationary organisms. A survey of benthic organisms provides a gross analysis of water quality in a given area of stream. For this reason, samples for both water quality and biological analyses were collected at selected points at each of the treatment plant sites. This will provide a separate chemical and biological evaluation at each of the treatment plant sites.

SURVEY DESCRIPTION

Selection of the mine drainage treatment plants was based on several factors including location, quantity and quality of mine effluent, and travel time between sites. In the final selection, three sites, operated by the Jones and Laughlin Steel Corporation, were chosen for the study. A letter of request was submitted to the appropriate Jones and Laughlin official and permission was obtained to visit the sites as required. No time period was allotted for our sampling run and personnel from the Wheeling Field Office were able to visit the treatment plant sites at any time during the course of study. The three selected sites were the Bercik, Kefover and Thompson mine drainage treatment plants.

A fourth site was also selected as a control station. This site represented an untreated effluent from an active mine which discharges to a tributary unaffected by mine drainage above the selected point of discharge. This site was located on Little Indian Creek north of Rivesville, West Virginia.

FIELD PROCEDURES - CHEMICAL SAMPLING

With respect to relative location, identical sampling points were selected at each treatment plant site. A background sampling point was selected at each site above the treatment plant. Since each receiving tributary was unaffected by either active or abandoned mine drainage, the sampling point was indicative of the natural unaltered stream water quality. Additional sampling points included the raw mine water before treatment and also the final effluent representing the quality of water discharged to the receiving stream. A fourth sample was collected from the receiving stream a short distance below the point where the final effluent entered that particular receiving stream.

A total of four samples were collected at each site. This represented one complete round at each site during the months of May, June, July and August of 1972. During the May sampling round, the collected samples were analyzed for conventional mine drainage parameters. These parameters included acidity, alkalinity, sulfates, dissolved iron and suspended iron. The total iron concentration was obtained by combining the dissolved and suspended iron components.

During the subsequent samplings, ten additional parameters were determined for each site. These parameters included manganese, aluminum, calcium, magnesium, cadmium, chromium, copper, lead, nickel and zinc. Analyses for these metals were considered in a general attempt to further evaluate the efficiency of a conventional mine drainage treatment plant for the removal or reduction of metals not commonly associated with mine drainage but often present in measurable quantities.

FIELD PROCEDURES - BIOLOGICAL SAMPLING

Changes in water quality produce different responses from different aquatic organisms. There are some aquatic organisms which can survive and flourish in heavily polluted waters and there are other organisms which cannot survive in waters even slightly polluted. This is true of benthos, plankton and fish. Benthic organisms are used frequently in water pollution surveys as water quality indicators because they are relatively stationary organisms. Fish and plankton can be less effective in demonstrating pollution conditions than the benthos because fish may avoid polluted water by swimming away and the plankton effects may not be readily measured because of stream drifting.

A survey of the benthic organisms provides a gross analysis of water quality in a given area of stream. By using biological data and descriptions, one can delineate sections of a stream into unpolluted zones capable of supporting a varied population of aquatic organisms and polluted zones which support altered aquatic communities.

Three sampling stations were set up at each of the four sites. The first station at each site was located upstream of the discharge. This station is a reference or background station. The second station at each site was located below the discharge. The proximity of the station to the discharge was dependent on substrate conditions. The purpose of this station was to measure the maximum impact of the discharge on the benthic community. The third station at each site was located at a distance below the discharge to insure that the receiving stream and the discharge were completely mixed. This station measured the general impact of the discharge on the stream and also gave some indication of any immediate downstream recovery.

Bottom samples were collected once at each of the twelve stations. A Surber square foot sampler was used and samples were all collected in shallow riffle areas. The material collected was placed in quart jars and preserved for transportation to the laboratory, where the organisms were separated and identified. Multi-plate artificial substrates were also utilized for the biological study. These samplers were similar to the one described in the 13th edition of Standard Methods (1). The sampler exposes approximately one square foot of surface area for the attachment of organisms.

Two multi-plate samplers were suspended in the water column at each of the twelve stations. The exposure period for the samplers was approximately one month and three exposure periods were used at each station. These samplers were suspended both vertically and horizontally in the water column.

At the end of the exposure period, the samplers were carefully removed from the water, detached from their holding devices, and placed in one gallon buckets filled with a five percent solution of formalin. The samplers were taken to the laboratory, disassembled, brushed with a stiff bristle brush, and the organisms were concentrated in a U. S. Standard No. 30 sieve.

Each sample was sorted, counted and identified. The identification of the insects, clams and crustaceans was carried to the family taxonomic level. All the other groups were identified to the class or order taxonomic level except the Phylum Nematoda. The Family Hydridae was counted as a taxonomic group but the number of these collected at any given station was not counted in the total number of organisms collected at that station.

The taxa collected were divided into three classes based on their tolerance to mine drainage. The three classes are as follows: Class I, organisms intolerant of mine drainage; Class II, organisms which are tolerant to some constituents of mine drainage to some degree; Class III, organisms which are tolerant to mine drainage. The classification of the taxonomic groups, as described in this report, is preliminary and any reference made to this classification system should identify it as such. This system will be revised and updated as more information is gained and more data is collected. The classification system used in this report is based on observed tolerances of the various groups as reported in the literature, i. e., Griffith (2), Reppert (3), Dinsmore (4), etc., and upon personal observations of various benthic associations encountered in both affected and unaffected water. Published and unpublished data developed by the Wheeling Field Office was also used in establishing the system.

A diversity index was applied to samples collected as a matter of interest to see how such an index would relate to the observed results. The following index, taken from Wilhm (5) was used:

$$d = \frac{s-1}{LnN}$$

Where d is the diversity index, s is the number of taxa and LnN is the natural logarithm of the number of individuals per sample. The larger the diversity index, the better the water quality, because the diversity index represents the wealth of taxa as related to total number of organisms per sample. Maximum diversity exists if each individual is in a different taxa and minimum diversity exists if all individuals belong to the same taxa.

STATE REQUIREMENTS

The Pennsylvania Department of Environmental Resources requires active mine discharges to meet effluent guidelines imposed by the Commonwealth. In general, these requirements limit the pH value to between 6.0 and 9.0 standard units, require a total iron concentration of 7 mg/l or less, and require a final effluent exhibiting net alkalinity.

Although these are the effluent criteria imposed by the Commonwealth on active underground mine discharges under the 1965 amended Clean Streams Law, the water quality standards of the receiving stream are also of prime importance in determining the compliance status of a particular mine drainage discharge. A 1.5 mg/l total iron concentration has been adopted by the Commonwealth for streams in the Pennsylvania portion of the Monongahela River basin.

A permit is required from the DER for each point of mine drainage discharge from an active mine. The effluent requirements for each discharge are specified in the permit. As conditions require, the discharge may exceed the guidelines listed above or conversely it may require more restrictive limitations. The DER may also require limitations on other mine drainage parameters such as aluminum, manganese, sulfates, etc., as deemed necessary.

DESCRIPTION OF SITES

The three Jones and Laughlin treatment plants were located in

Washington County, Pennsylvania. The Bercik plant was located on an unnamed tributary to Pike Run which, in turn, is a tributary to the Monongahela River near the community of Coal Center. The Kefover plant was located on Daniels Run and the Thompson plant was located on Plum Run. Both Daniels Run and Plum Run are tributaries to Tenmile Creek, which enters the Monongahela River at Millsboro, Pennsylvania.

The control site representing an active untreated discharge was located on Little Indian Creek, a tributary to Indian Creek which joins the Monongahela River at Everettville, West Virginia.

The tributaries on which these four sites are located are unaffected by any active or abandoned mine discharges along the entire length of stream under consideration.

BERCIK TREATMENT PLANT

This facility provided lime neutralization followed by aeration and sedimentation. Acidity was not a major problem in the raw mine water effluent; however, the initial iron concentration was excessive. At an earlier visit to this site (12/71), only sedimentation and mechanical aeration were supplied. However, at the time of the first sampling for this study, the facility had been upgraded by the installation of the lime addition apparatus and an electrical aerator.

After alkalinization and aeration, the effluent was gravity fed to a series of three sedimentation ponds. The final effluent from the third pond is discharged to an unnamed tributary of Pike Run (Figure 1).

During the period of sampling, this mine effluent was characterized by a comparatively large discharge which averaged 1,928 gpm. The alkalinity concentration of the raw effluent generally exceeded the acidity concentration and the total iron concentration was 50 mg/l or less.

The chemical and biological sampling points associated with the Bercik mine drainage treatment plant are shown in Figure 1. Table 1 lists the chemical data collected during the four sampling periods.

CHEMICAL EVALUATION

The raw water pumped to the surface at the Bercik borehole was alkaline on three of the four sampling occasions. However, the total iron concentration ranged from 20 to 50 mg/l. This initial total iron concentration was reduced by treatment to a range of 3 to 6 mg/l in the final effluent. It is noteworthy that the dissolved iron portion of this total iron concentration averaged only 0.5 mg/l while the suspended iron fraction accounted for the major portion of the iron which was measured. There was no suspended iron present in the untreated raw water discharge, and the final effluent exhibited a suspended iron concentration ranging from 2 to 6 mg/l.

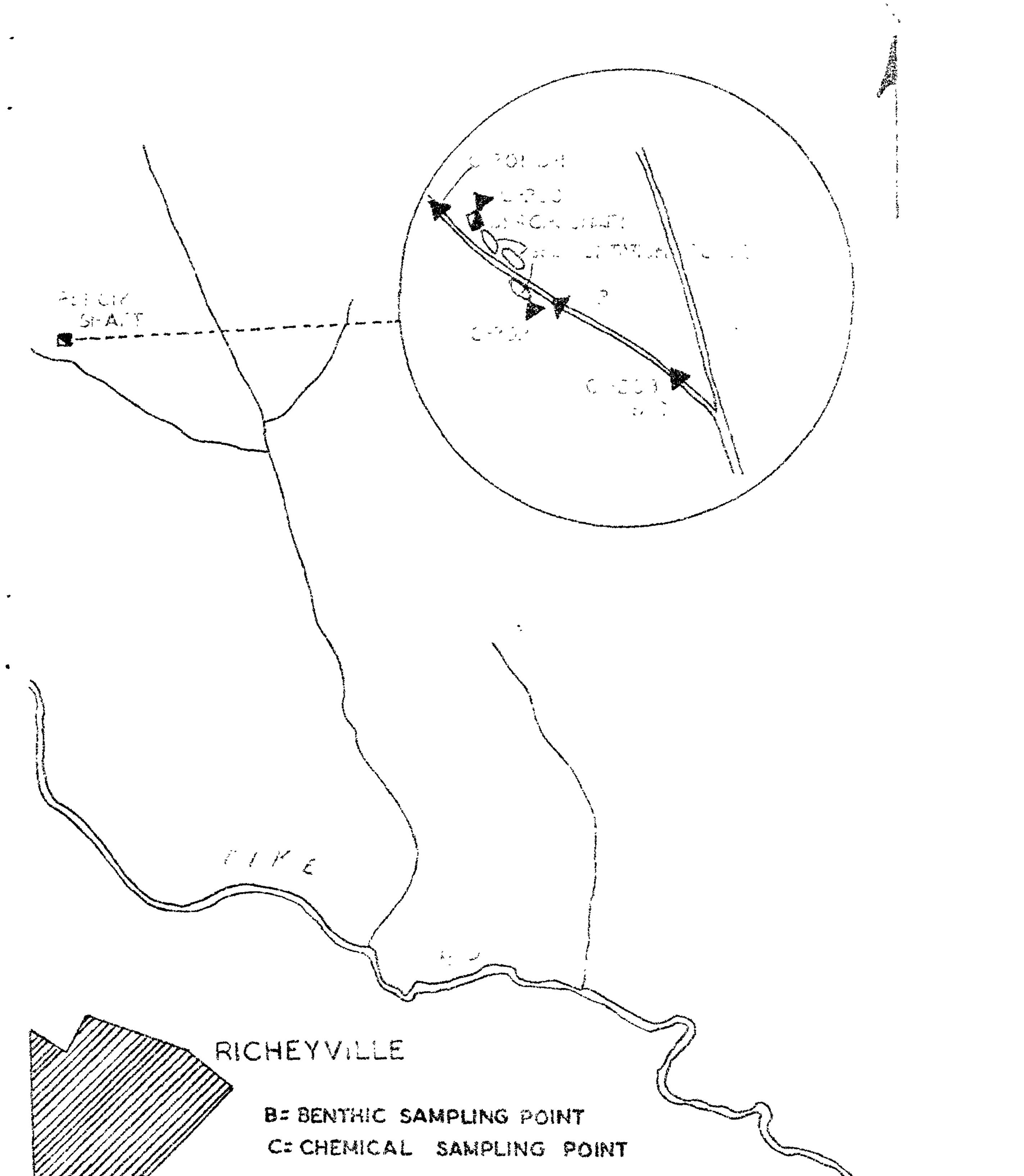
RICHEYVILLE
B= BENTHIC SAMPLING POINT
C= CHEMICAL SAMPLING POINT

FIGURE 1

[illegible]

Table 1

Water Quality Data

Bercik Treatment Plant

	Background (C-201)				Untreated Discharge (C-200)				Treated Discharge (C-202)				Downstream (C-203)			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72
pH	6.9	7.3	7.7	7.5	6.6	6.9	7.1	7.0	6.4	7.4	7.3	7.1	7.5	7.7	7.5	7.4
Specific Conductance	570	600	520	650	2300	2500	3000	2700	2800	2800	2700	2600	2500	2500	2700	2600
Flow-gpm	-	-	-	-	-	-	-	-	2240	1885	1508	2080	-	2806	3018	-
Net Alkalinity mg/l	-61*	175	194	-	-177	81	39	203	47	82	130	244	112	75	120	222
Dissolved Iron-mg/l	0	0	0	1	50	50	20	45	1	1	0	0	0.5	0.5	0	0
Suspended Iron-mg/l	0.5	1	0	0	0	0	0	0	4	2	2	6	3.5	2.5	3	6
Total Iron mg/l	0.5	1	0	1	50	50	20	45	5	3	2	6	4	3.0	3	6
Sulfate mg/l	45	65	55	120	1530	825	900	750	1365	850	930	775	1380	775	960	750
Manganese mg/l	-	0.1	4	0	-	5	5	4	-	5	4	4	-	5	4	5
Aluminum mg/l	-	0	0	0	-	0	0	1	-	0	0	0	-	0	0	0

*Negative value denotes acidity.

Table [illegible] (continued)

Water Quality Data

Bercik Treatment Plant

	Background (C-201)				Untreated Discharge (C-200)				Treated Discharge (C-202)				Downstream (C-203)			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72
Calcium mg/l	-	55	50	60	-	200	200	300	-	200	200	320	-	200	200	300
Magnesium mg/l	-	17	[illegible]	20	-	70	50	65	-	60	60	60	-	50	50	65
Cadmium ug/l		0	0	0	-	10	20	21	-	10	20	16	-	10	20	19
Chromium ug/l	-	0	0	[illegible]	-	20	0	41	-	10	20	25		0	0	36
Copper ug/l	-	0	50	8	-	0	0	10		0	0	0	-	0	50	10
Lead ug/l	-	0	0	20	-	20	0	60	-	20	0	20	-	40	0	20
Nickel ug/l	-	20	40	5	-	70	80	60	-	50	40	42	-	50	0	55
Zinc ug/l	-	10	0	0	-	20	20	22	-	20	20	13	-	10	20	20

The three large sedimentation ponds at Bercik have been in operation for 7 or 8 years. During this time, sludge removal has been somewhat minimal due to the large area available for sedimentation. However, the long-term accumulation of sediment (iron floc) was becoming a problem at the Bercik site. In the treatment process, the dissolved iron is converted to the insoluble state for precipitation. However, due at least in part to the chemical composition of the mine water before and after treatment and the reduced capacity of the available sedimentation area, a significant portion of the iron concentration was discharged to the receiving stream in the suspended state.

As would be expected from the above discussion, the total iron concentration carried by the receiving stream (C-203) below the Bercik discharge, represented a significant increase in comparison with the total iron concentration exhibited by the background sampling point (C-201) above the Bercik discharge. The background total iron concentrations ranged from 0 mg/l to 1 mg/l and the downstream values ranged from 3 to 6 mg/l. This iron was generally present in the form of ferric hydroxide and/or ferric sulfate which were responsible for staining and coating the banks and bottom of a downstream length of the receiving tributary.

The alkalinity concentration of the receiving stream was reduced by the Bercik discharge on two of the four sampling occasions. However, on one occasion the alkalinity was increased. There were no significant changes in the pH values of the receiving stream below the Bercik outfall. As expected, the sulfate concentrations in the receiving stream were greatly increased. At the upstream point, the sulfate values ranged from 45 to 120 mg/l while the downstream point values ranged from 750 mg/l to 1,380 mg/l.

BIOLOGICAL EVALUATION

Descriptions of the three biological sampling stations associated with the Bercik treatment plant are given below. Tables 2, 3 and 4 represent the biological data collected at these points.

The number of organisms and taxa collected at the two downstream stations was well below the numbers collected at the upstream station. The following is a more detailed description of the results obtained at each station.

Station B-1 (Upstream of Discharge)

The substrate at this station was composed of a mixture of rock, rubble, gravel and sand (Table 2). Stream bottom conditions appeared to be very stable. The number of taxa collected at this station, 21, (Table 3) was the most collected at any of the stations during the study and also yielded the highest diversity index of 3.50. The organisms were well distributed among several taxonomic groups. Eleven Class I taxa and nine Class II taxa were collected; however, there was a total of 147 Class II organisms (Figure 5) and 106 Class I organisms.

Table 2
Benthos Sampling Stations
Bercik Treatment Plant

Station Number	Sampling Dates	Station Location	Substrate Description	Comments
B-1	5/16 5/16 to 6/16 6/16 to 7/24 7/24 to 8/21	X-Trib. to Pike Run approximately 275 yards above the discharge.	Riffle Areas* 10% Rock 20% Rubble 20% C.Gravel 20% F.Gravel 20% C.Sand 10% F.Sand Pool Areas Consisted mainly of bedrock	The dendys collected on 7/24 were knocked over and laying on their side
B-2	5/16 5/16 to 6/16 6/16 to 7/24 7/24 to 8/21	X-Trib. to Pike Run approximately 30 yards below the discharge.	Riffle Area 10% Rock 5% Rubble 50% C.Gravel 15% F.Gravel 10% C.Sand 10% F.Sand Pool Areas Mostly bedrock with some gravel.	
B-3	5/16 5/16 to 6/16 6/16 to 7/24 7/24 to 8/21	X-Trib. to Pike Run approximately 300 yards below the discharge.	Riffle Areas 5% Rock 5% Rubble 50% C.Gravel 30% F.Gravel 10% C.Sand 10% F.Sand Pool Areas Bottoms consisted mainly of clay and gravel.	One dendy collected on 7/24/ had been knocked over and was laying on its side.

*Bottom compositions are estimates based on field observations.

Table 3

Benthos Data Summary
Bercik Treatment Plant

Station Number	Sampling Dates	No. of Samples	Type of Sample	Total No. of Organisms	No. of Taxa collected	Diversity Index	% of Class I	% of Class II	% of Class III
B-1	5/16	1	S *	301	21	3.50	35	49	16
	5/16 to 6/16	1	D **	76	4	0.70	0	3	97
	5/16 to 6/16	1	D	28	1	∅	0	0	100
	6/16 to 7/24	1	D	66	5	0.95	6	6	88
	6/16 to 7/24	1	D	93	8	1.54	4	4	92
	7/24 to 8/21	1	D	9	1	∅	0	0	100
	7/24 to 8/21	1	D	28	5	1.20	11	46	43
B-2	5/16	1	S	16	3	0.72	6	44	50
	5/16 to 6/16	1	D	225	3	0.62	12	12	76
	5/16 to 6/16	1	D	59	6	1.23	7	66	27
	6/16 to 7/24	1	D	1	1	∅	0	100	0
	6/16 to 7/24	1	D	55	4	0.75	2	94	4
	7/24 to 8/21	1	D	0	0	∅	0	0	0
	7/24 to 8/21	1	D	1	1	∅	0	0	100
B-3	5/16	1	S	45	9	2.10	11	31	58
	5/16 to 6/16	1	D	6	3	0.56	17	17	66
	5/16 to 6/16	1	D	4	1	∅	0	0	100
	6/16 to 7/24	1	D	7	5	2.09	0	71	29
	6/16 to 7/24	1	D	11	7	2.50	27	64	9
	7/24 to 8/21	1	D	11	1	∅	0	0	100
	7/24 to 8/21	1	D	0	0	∅	0	0	0

* Surber Samples
** Artificial Substrate Samples

Table 8

Benthos Data

Bercik Treatment Plant

Class I	B-1·	B-1b	B-1b	B-1c	B-1c	B-1d	B-1d	B-2a	B-2b	B-2b	B-2c	B-2c	B-2d	B-2d	B-3a	B-3b	B-3b	B-3c	B-3c	B-
<u>Caddisflies</u>																				
Hydroptilidae	11														3					
Philopotamidae	1																			
Psychomyiidae	2																			
<u>Stoneflies</u>																				
Perlidae	1									1					2	1				
Perlodidae	1																			
<u>Mayflies</u>																				
Heptageniidae	33				2															
<u>Crustaceans</u>																				
Astacidae	1				1															
Isopoda	43			1															1	
<u>Flatworms</u>																				
Turbellaria	5									3		1							1	
<u>Roundworms</u>																				
Nematode	1							1	3										1	
<u>Fingernail Clams</u>																				
Sphaeriidae				3	1															
<u>Crane Flies</u>																				
Tipulidae	7																			
<u>Leeches</u>																				
Hirudinea							3													
Class II																				
<u>Caddisflies</u>																				
Hydropsychidae	47							7		32	1	15			1			2		

Table 4 — Continued

Benthos Data
Bercik Treatment Plant

Class II (cont'd)

	B-1a	B-1b	B-1b	B-1c	B-1c	B-1d	B-1d	B-2a	B-2b	B-2b	B-2c	B-2c	B-2d	B-2d	B-3a	B-3b	B-3b	B-3c	B-3c
Stoneflies																			
Nemouridae	24														1				
Mayflies																			
Baetidae	30	1			1														
Beetle Larvae																			
Elmidae	6														1			1	
Dryopidae	1																		
Dytiscidae				3															
Hydrophilidae																		1	
Crustaceans																			
Amphipoda	34				1					6		37			8			1	4
Snails																			
Pulmonata					1		1												
Dance Flies																			
Empididae	2														2				
Black Flies																			
Simuliidae	1																		
Horse Flies																			
Tabanidae					1														
Damselflies																			
Coenagrionidae							1												
Aquatic Worms																			
Oligochaeta	2	1		1			11		3	1					1	1		2	1

continued

Benthos Data
Bercik Treatment Plant

Class III

	B-1a	B-1b	B-1b	B-1c	B-1c	B-1d	B-1d	B-2a	B-2b	B-2b	B-2c	B-2c	B-2d	B-2d	B-3a	B-3b	B-3b	B-3c	B-3c …
<u>Megaloptera</u>																			
Sialidae		2																	
<u>Midge Flies</u>																			
Chironomidae	48	72	28	58	85	9	12	8	19	16		2		1	26	4	4	2	1

The benthic community at this station is what one would expect to collect in a small stream with good water quality.

Station B-2 (30 yards below discharge)

About 65 percent of the substrate at this station was gravel (Table 2) with the remainder being a combination of rock, rubble and sand. Red stains were present on the substrate and suspended iron particles produced a reddish tint in the water. Only 16 organisms and 3 taxa (Table 3) were collected at this station. Class I organisms were reduced in number from 106 at Station B-1 to one at Station B-2 and from 11 taxa at Station B-1 to one taxon at Station B-2. Class II organisms were similarly reduced in number and taxa. At Station B-1, there were 147 Class II organisms in 10 taxa and at Station B-2 there were 7 organisms in one taxa. The number of Chironomidae were reduced from 48 at Station B-1 to 8 at Station B-2. The total numbers and variety of the benthic community at this station was severely depressed. The substrate may be partly attributable for the poor macroinvertebrate community, however, the major problem is the degradation of the stream water quality by the discharge, indicating a toxic effect.

Station B-3

The substrate at this station was not favorable for aquatic life as it was composed of about 80 percent gravel with very little rock and rubble. Suspended iron particles were also visible in the water at this Station and the substrate was stained red. The benthic community was slightly improved over the one at Station B-2; however, it still did not begin to compare with the benthic community found at the background station. There was a total of 45 organisms and 9 taxa collected at this station with a resulting diversity index of 2.10. The number of taxa in Class II increased from one at Station B-2 to six at this station and the number of Class II organisms was doubled. The number of Chironomidae increased from 8 at Station B-2 to 26 at Station B-3. Class I organisms also showed some small increase by 4 individuals and one taxon. The small increase in total organisms and the number of taxa from Station B-2 to Station B-3 appears to be influenced by substrate composition because the water quality at both stations is nearly identical.

KEFOVER TREATMENT PLANT

The Kefover mine drainage treatment plant is located on Plum Run just north of the community of Marianna, Pennsylvania. Raw mine water is pumped to the surface and channelled to a single large sedimentation pond. Lime is slurry fed to the effluent prior to discharge to the sedimentation pond. The existing system was somewhat temporary and an upgraded facility was under construction at the time of survey. The upgrading will probably be primarily directed toward an increase in capacity of the lime holding tank and a decrease in maintenance time required for plant operation. However, the system in use was quite adequate with respect to the production of a final discharge exhibiting satisfactory water quality.

The chemical and biological sampling points associated with the Kefover site are shown in Figure 2. Table 5 lists the chemical data collected during the four sampling periods.

CHEMICAL EVALUATION

The acidity concentration of the raw water discharge at the Kefover site ranged from 100 mg/l to 610 mg/l for three samples. On the fourth sampling, the discharge exhibited a net alkalinity of 95 mg/l. The total iron concentration of the untreated effluent ranged from 15 mg/l to 60 mg/l. Suspended iron was present in three of the four samples.

The treated Kefover discharge exhibited an average net alkalinity of 111 mg/l during the sampling period. The corresponding pH values ranged from 6.8 to 7.1. An average discharge rate of 168 gpm was measured at this plant.

Iron removal at the Kefover site was quite adequate. On one occasion, the treated effluent exhibited a total iron concentration of 3 mg/l; however, during the other sampling periods, the iron concentration averaged only 0.4 mg/l. As a result of the neutralization process, the sulfate concentration averaged 1,875 mg/l in the treated discharge. On two of the three samples, where the presence of aluminum was detected, initial raw water concentrations of 45 mg/l and 24 mg/l were both reduced to zero by the treatment process. Initial concentrations of such trace metals as cadmium, copper and zinc were

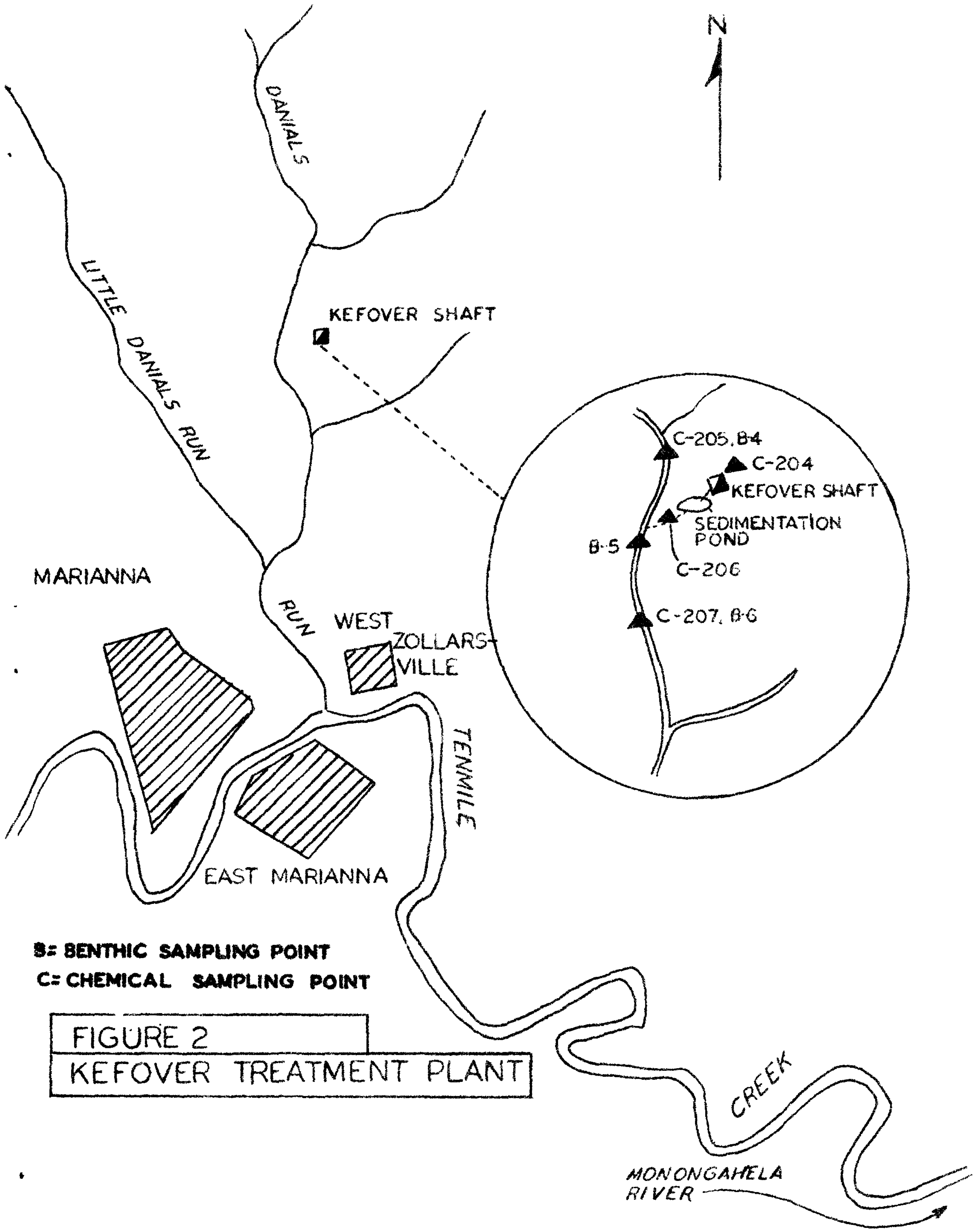

FIGURE 2
KEFOVER TREATMENT PLANT

Table 5
Water Quality Data
Kefover Treatment Plant

	Background (C-205)				Untreated Discharge (C-204)				Treated Discharge (C-206)				Downstream C-207)			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72
pH	6.8	7.3	7.8	7.8	4.6	4.5	6.7	5.5	6.8	6.9	7.0	7.1	7.7	7.5	8.0	7.5
Specific Conductance	550	650	540	650	7000	8000	8000	8000	8000	8000	7400	8000	1400	1200	1000	2100
Flow-gpm	-	-	-	-	-	-	-	-	-	174	180	150	2406	1132	2120	-
Net Alkalinity-mg/l	168	142	194	-	-610*	-590	95	-100	135	30	90	188	78	106	182	209
Dissolved Iron-mg/l	0.5	0.3	0	0	25	15	15	40	0.3	0.5	0	0.2	0.3	1	0	0
Suspended Iron-mg/l	0	0	0	0	35	11	0	18	0.2	0	3	0	0	0	0	0
Total Iron mg/l	0.5	0.3	0	0	60	25	15	58	0.5	0.5	3	0.2	0.3	1	0	0
Sulfate mg/l	65	60	65	70	3375	2100	1700	2300	2800	2100	1200	1400	255	310	200	560
Manganese mg/l	-	0	3	0	-	7	0	5	-	6	0	3	-	1	7	0
Aluminum mg/l	-	0	0	0	-	45	0	24	-	0	0	0	-	0	0	0

*Negative value denotes acidity.

(continued).

Table 5
Water Quality Data
Kefover Treatment Plant

	Background (C-205)				Untreated Discharge (C-204)				Treated Discharge (C-206)				Downstream C-207)			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72
Calcium mg/l	-	50	50	120	-	200	210	390	-	200	300	80	-	75	70	150
Magnesium mg/l	-	10	10	12	-	25	75	100	-	115	75	85	-	15	15	30
Cadmium ug/l	-	5	0	70	-	20	20	560	-	5	0	42	-	0	0	20
Chromium ug/l	-	0	0	0	-	30	20	18	-	0	20	80	-	0	0	20
Copper ug/l	-	5	0	0	-	100	100	65	-	5	0	20	-	0	0	25
Lead ug/l	-	0	0	-	-	50	0	30	-	20	0	20	-	0	0	20
Nickel ug/l	-	10	0	5	-	500	100	450	-	400	100	300	-	50	0	36
Zinc	-	10	20	7	-	700	300	580	-	200	70	40	-	40	20	15

reduced to a lower level of concentration by the treatment process.

At the upstream sampling point (C-205), the pH value ranged from 6.8 to 7.8 and exhibited an average net alkalinity of 168 mg/l. At the stream sampling point below the Kefover discharge (C-207), the pH value ranged from 7.5 to 8.0 and exhibited an average net alkalinity of 144 mg/l. During the period of sampling, there was no significant increase in the total iron concentration carried by the receiving stream. Above the discharge point, the tributary carried an average iron concentration of 0.2 mg/l and below the discharge, the average was 0.3 mg/l. Sulfate values averaged 65 mg/l at the background station and 341 mg/l at the downstream sampling point.

BIOLOGICAL EVALUATION

Descriptions of the three biological sampling stations associated with the Kefover plant are given below. Tables 6, 7 and 8 present the biological data collected at these points.

The total number of organisms collected at the three stations (Figure 6) declined in downstream order; however, the diversity indices for the three stations remained relatively constant. The principle group collected at the stations was the dipteran family, Chironomidae. The following is a more detailed description of the results obtained at each station.

Table 6
Benthos Sampling Stations
Kefover Treatment Plant

Station No.	Sampling Dates	Station Location	Substrate Description	Comments
B-4	5/16 5/16 to 6/16 6/16 to 7/24 7/24 to 8/21	Daniels Run approximately 200 yards upstream of the discharge.	Riffle Areas* 10% rock 30% rubble 30% C.Gravel 10% F.Gravel 10% C.Sand 10% F.Sand Pool Areas Bottoms consisted mainly of "bedrock"	The dendy, the last collected 7/24, had been moved about 25 feet downstream by the current.
B-5	5/16 5/16 to 6/16 6/16 to 7/24 7/24 to 8/21	Daniels Run approximately 50 yards below the discharge.	Riffle Areas 10% rock 50% rubble 20% C.Gravel 10% F.Gravel 10% C.Sand Pool Areas Bottoms consisted mainly of "bedrock"	
B-6	5/16 5/16 to 6/16 6/16 to 7/24 7/24 to 8/21	Daniels Run approximately 450 yards below the discharge.	Riffle Areas 10% rock 30% rubble 10% C.Gravel 10% F.Gravel 20% C.Sand 20% F.Sand Pool Areas Bottoms consisted mainly of "bedrock"	

*Bottom compositions are estimates based on field observations.

Table 7
Benthos Data Summary
Kefover Treatment Plant

Station Number	Sampling Dates	No. of Samples	Type of Sample	Total No. of Organisms	No. of taxa collected	Diversity Index	% of Class I	% of Class II	% of Class III
B-4	5/16	1	S*	440	18	2.79	41	15	44
	5/16 to 6/16	1	D**	93	3	0.44	0	2	98
	6/16 to 7/24	1	D	30	3	0.58	3	7	90
	7/24 to 8/21	1	D	52	3	0.50	0	4	96
B-5	5/16	1	S	338	15	2.40	58	17	25
	5/16 to 6/16	1	D	108	4	0.64	0	4	96
	5/16 to 6/16	1	D	182	6	0.96	1	7	92
	6/16 to 7/24	1	D	107	3	0.43	0	13	87
	7/24 to 8/21	1	D	28	1	Ø	0	0	100
	7/24 to 8/21	1	D	59	2	0.25	0	2	98
B-6	5/16	1	S	246	15	2.54	10	25	65
	5/16 to 6/16	1	D	78	4	0.69	1	3	96
	5/16 to 6/16	1	D	88	1	Ø	0	0	100
	6/16 to 7/24	1	D	47	1	Ø	0	0	100
	7/24 to 8/21	1	D	32	1	Ø	0	0	100

*Surber Samples

**Artificial Substrate Samples

Table 8
Benthos Data
Kefover Treatment Plant

	B-4a	B-4b	B-4c	B-4d	B-5a	B-5b	B-5b	B-5c	B-5d	B-5d	B-6a	B-6b	B-6b	B-6c	B-6d
Class I															
Caddisflies															
Hydroptilidae	140				182						13				
Philopotamidae	21				8						6				
Psychomyiidae			1				1								
Heliopsychidae	1														
Stoneflies															
Perlidae	4				6						3	1			
Mayflies															
Heptageniidae	6										3				
Crustaceans															
Isopoda	2														
Flatworms															
Turbellaria	4														
Roundworms															
Nematoda	1														
Fingernail Clams															
Sphaeriidae					1										
Crane Flies															
Tipuliidae	1														
Coelenterata															
Hydridae						-	-*					-			
Class II															
Caddisflies															
Hydropsychidae	7			1	18		2	13			5				

*The numbers of these organisms were not counted.

Table 8
Benthos Data
Kefover Treatment Plant

Continued

Class II (cont'd)	B-4a	B-4b	B-4c	B-4d	B-5a	B-5b	B-5b	B-5c	B-5d	B-5d	B-6a	B-6b	B-6b	B-6c	B-6d
<u>Stoneflies</u>															
Nemouridae	1				1						2				
<u>Mayflies</u>															
Baetidae	17		2	1	4	1					22				
<u>Megaloptera</u>															
Corydalidae					1						1				
<u>Biting Midge</u>															
Ceratopogonidae	1														
<u>Beatle Larvae</u>															
Elmidae	15				17						19				
Psephenidae											2				
<u>Crustaceans</u>															
Amphipoda	1				2										
<u>Snails</u>															
Pulmonata							1				1				
<u>Black Flies</u>															
Simuliidae	9				6						7				
<u>Dance Flies</u>															
Empididae					5			1			2				
<u>Damselfly</u>															
Agrionidae										1					
<u>Aquatic Worms</u>															
Oligochaeta	17	2			3	3	11				1	2			

Table 8 Continued
Benthos Data
Kefover Treatment Plant

Class III	B-4a	B-4b	B-4c	B-4d	B-5a	B-5b	B-5b	B-5e	B-5d	B-5d	B-6a	B-6b	B-6b	B-6c	B-6a
<u>Megaloptera</u>															
Sialidae		1													
<u>Midge Flies</u>															
Chironomidae	192	90	27	50	84	104	167	93	28	58	159	75	88	47	32

Station B-4 (upstream of discharge)

The substrate at this station was stable and consisted primarily of rubble and gravel (Table 6). There was no evidence of any siltation problems. The principle land use above this station was agricultural with its associated housing. The stream was organically enriched as indicated by an abundant growth of algae attached to the surface of the substrate. This growth provided a habitat for the large numbers of Hydroptilidae and Chironomidae larvae collected at this station. There was a total of nine taxa at this station in Class I and eight taxa in Class II with one group in Class III.

Station B-5 (50 yards below discharge)

The physical characteristics of this station were almost identical to Station 4. The substrate material at this station was also coated with a thick growth of algae. The total number of organisms and the number of taxa collected at this station were less than those found at Station B-4. Although the percentage of Class I organisms increased at Station B-5, the number of taxa in Class I was reduced from 9 at Station B-4 to four at Station B-5. The increase in Class I organisms is due totally to the numbers of Hydroptilidae. The discharge affects all the Class I organisms except the Hydroptilidae and Perlidae. The organisms in Class II were reduced in number by only 8 and gained one taxon; they were not greatly affected by this discharge. The large reduction in the number of midge is the major difference in total numbers of organisms between Station B-4 and Station B-5. The bar graphs representing numbers shown on Figure 5 do not accurately express the impact of the discharge on the stream due to the large number of Hydroptilidae.

Station B-6 (450 yards below discharge)

The substrate at this station consisted mostly of various sands and rubble. There was not a dense algal growth on the substrate as there was at Stations B-4 and B-5. The total number of organisms at this station was reduced further while the number of taxa remains the same as Station B-5 and only three less than Station B-4. The percentage composition by Class differs greatly with those at Stations B-4 and B-5. The substrate at this station affects the benthic fauna as much as the discharge itself. The great reduction in the Hydroptilidae population is the significant difference in Class I organisms at this station as opposed to the upstream stations, and this can be attributed to the loss of habitat rather than any changes in water quality. No significant differences are present between this station and Stations B-4 and B-5 in relation to the Class II organisms.

THOMPSON TREATMENT PLANT

This lime neutralization facility is located on an unnamed tributary to Plum Run which, in turn, joins Tenmile Creek near the community of Fairfield, Pennsylvania. The raw mine water is pumped to a holding pond above the treatment plant. From this point, the mine water is piped through the plant. Additional mixing and some aeration of the alkalinized effluent is supplied by a V-notched baffling device prior to discharge to a single sedimentation pond. A portion of the treated effluent is diverted (when necessary) to a small fish pond adjacent to the sedimentation pond.

The chemical and biological sampling points associated with the Thompson site are shown in Figure 3. Table 9 lists the chemical data collected during the four sampling periods.

CHEMICAL EVALUATION

Cleaning operations were underway at the raw water holding pond at the Thompson site during the first sampling round. Since only one holding pond was available at this site, a temporary makeshift treatment procedure, not indicative or normal plant procedure, was in operation at the time of visit. The portion of the raw water discharge which exceeded the capacity of the treatment plant was pumped directly (without treatment) to the sedimentation pond. This raw water was then combined in this pond with the treated effluent discharged by the plant. The end result of this activity was a final discharge which exhibited an acidity concentration of 115 mg/l and carried a total iron concentration of 50 mg/l. During the sample period, the background alkalinity of 177 mg/l in the receiving stream was totally depleted with a resultant acidity concentration of 63 mg/l.

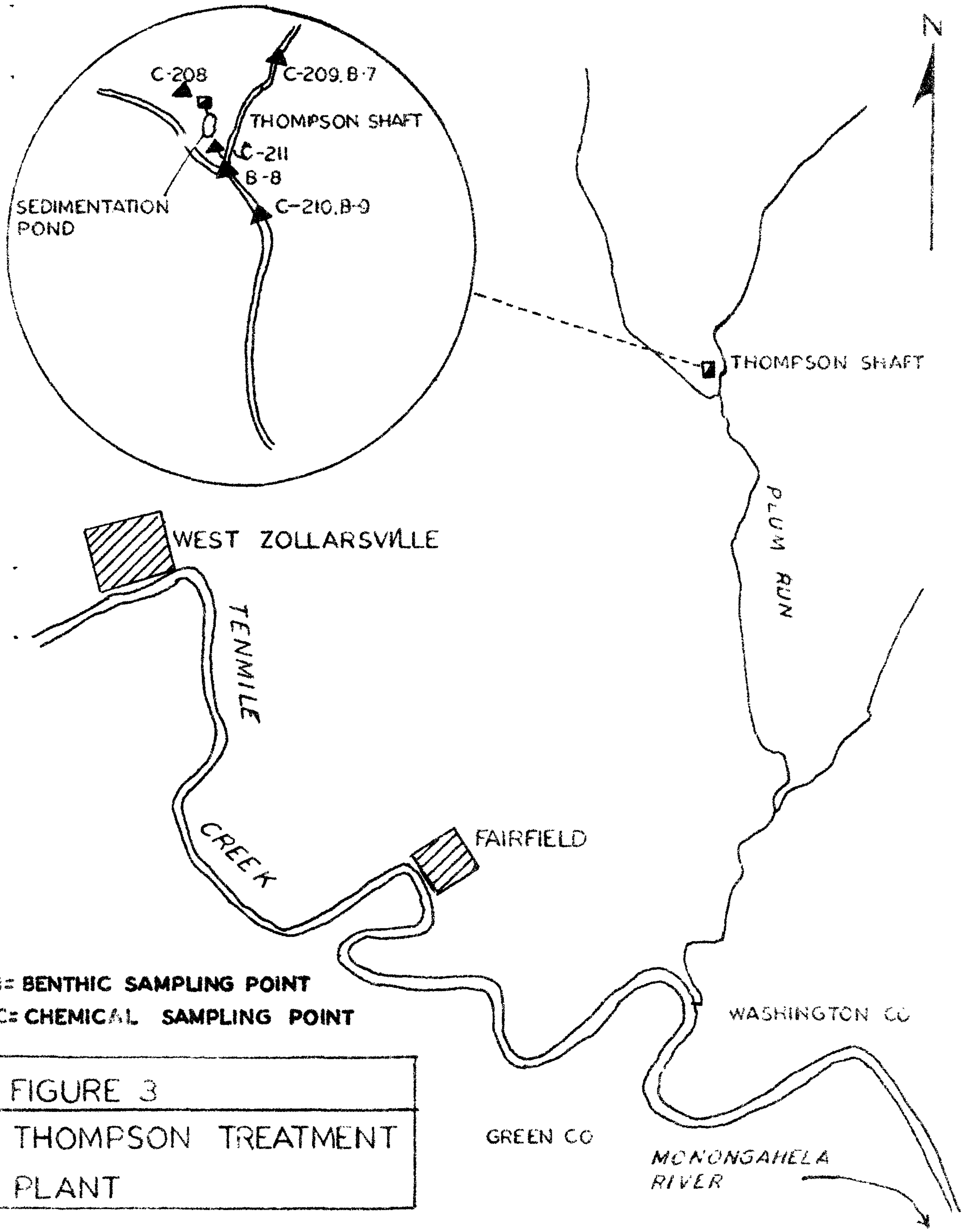

FIGURE 3

THOMPSON TREATMENT PLANT

Table 9

Water Quality Data

Thompson Treatment Plant

	Background (C-209)				Untreated Discharge (C-208)				Treated Discharge (C-211)				Downstream (C-210)			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72
pH	7.8	7.2	7.6	7.8	3.2	3.4	3.1	3.1	8.0	7.2	7.3	7.6	6.9	7.5	7.5	7.4
Specific Conductance	750	1000	1000	1100	8000	5500	6000	5000	6000	5550	6000	4500	1100	1700	1900	2800
Flow-gpm	-	-	-	-	-	-	-	-	-	114	129	100	1531	833	858	-
Net Alkalinity-mg/l	177	110	186	186	1300*	-940*	-760*	-585*	-115*	7	35	43	-63*	103	163	144
Dissolved Iron-mg/l	0	0.5	0	0	100	100	160	100	50	0.3	0.5	0.5	1	0.3	0	0.2
S pended I on-mg/l	0.7	0.5	0	0.2	50	0	0	10	0	0.7	0	1.5	0	0.2	0	0.3
Total Iron mg/l	0.7	1.0	0	0.2	150	100	160	110	50	1	0.5	2.0	1	0.5	0	0.5
Sulfate mg/l	140	280	440	260	4000	2450	2150	2350	3450	2200	1700	1845	180	480	610	78[illegible]
Manganese mg/l	-	0.2	1	0	-	5	0	5	-	1.5	0	2	-	0.5	2	1
Aluminum mg/l	-	0	0	0	-	45	50	55	-	0	0	0	-	0	0	0

*Negative value denotes acidity.

(continued)

Table 9

Water Quality Data

Thompson Treatment Plant

	Background (C-209)				Untreated Discharge (C-208)				Treated Discharge (C-211)				Downstream (C-210)			
	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/72	6/72	7/72	8/72	5/7	6/72	7/72	8/72
Calcium mg/l	-	75	75	120	-	300	200	480	-	400	600	781	-	50	170	240
Magnesium mg/l	-	25	25	35	-	135	75	80	-	50	50	61	-	50	30	32
Cadmium ug/l	-	0	0	18	-	20	20	650	-	10	20	33	-	10	20	50
Chromium ug/l	-	0	20	0	-	40	40	57	-	0	30	10	-	0	20	10
Copper ug/l	-	0	0	0	-	100	5000	170	-	0	0	50	-	0	0	40
Lead ug/l	-	0	0	20	-	20	0	20	-	20	0	40	-	5	0	20
Nickel ug/l	-	20	0	20	-	500	200	600	-	60	80	200	-	20	0	73
Zinc ug/l	-	20	20	17	-	700	900	620	-	20	20	33	-	40	10	50

The following comments relate to the three subsequent sampling rounds at the Thompson plant when it was operating under normal conditions.

The Thompson raw water discharge carried average acid and iron concentrations of 762 mg/l and 123 mg/l, respectively. The aluminum concentration averaged 50 mg/l. The presence of trace metals, including cadmium, chromium, copper, nickel and zinc were detected on each of the three occasions which analyses for these metals were performed. Lead was present on two of the three occasions. After treatment, the high initial acidity was converted to a net alkalinity averaging 28 mg/l. The initial average total iron concentration (123 mg/l) was reduced to an average concentration of only 1.2 mg/l. The aluminum present in the raw water was completely removed by the treatment process. Zinc was the only trace metal which was significantly reduced by the treatment process. An initial average concentration of 740 micrograms per liter was reduced to 24 micrograms per liter in the treated discharge.

Above the Thompson plant, the pH values of the receiving stream ranged from 7.2 to 7.8. Below the Thompson outfall, the stream exhibited pH values ranging from 7.4 to 7.5. At the upstream point, the stream exhibited an average net alkalinity of 161 mg/l. Below the point of discharge, the stream carried an average net alkalinity of 137 mg/l. There was no significant change in the average total iron concentrations measured at the upstream and downstream points.

An avepage discharge rate of 114 gpm was measured at this site during the survey.

With the exception of the one instance described above, the Thompson plant provided excellent treatment with respect to the upgrading of the water quality exhibited by the final discharge from the facility.

BIOLOGICAL EVALUATION

Descriptions of the three biological sampling stations associated with the Thompson plant are given below. Tables 10, 11 and 12 present the biological data collected at these stations.

The diversity indices at the three stations at this site were gradually reduced from Station B-7 to Station B-9 while the total number of organisms was greatly reduced between Station B-7 and Station B-8, and increased between Station B-8 and Station B-9. The principle taxonomic group collected at the three stations was the dipteran family, Chironomidae. The following is a more detailed description of the results obtained at each station.

<u>Station B-7</u> (upstream of discharge)

The substrate at this station consisted primarily of rubble which (Table 10) provides a favorable habitat for benthic organisms. A total of 18 taxa and 302 organisms were collected at this station. Fifty-six percent of the organisms collected were in Class I; 19

Table 10
Benthos Sampling Stations
Thompson Treatment Plant

Station No.	Sampling Dates	Station Location	Substrate Description	Comments
B-7	5/17 5/17 to 6/16 6/16 to 7/24 7/24 to 8/21	Plum Run approximately 25 feet above the discharge.	Riffle Areas* 5% rock 45% rubble 10% C.Gravel 10% F.Gravel 10% F.Sand 20% clay Pool Areas A mixture of bedrock, fine silt and some clay.	One dendy collected on 7/24 was partially silted in.
B-8	5/17 5/17 to 6/16 6/16 to 7/24 7/24 to 8/21	Plum Run approximately 40 feet below the discharge.	Riffle Areas 10% rock 10% C.Gravel 10% F.Gravel 30% C.Sand 40% F.Sand Pool Areas A mixture of bedrock, fine silt and some clay.	One dendy collected on 7/24 was partially out of the water because of low flow.
B-9	5/17 5/17 to 6/16 6/16 to 7/24 7/24 to 8/21	Plum Run approximately 200 yards below the discharge.	Riffle Areas 20% rubble 10%C.Gravel 10% F.Gravel 30% C.Sand 20% F.Sand Pool Areas Mostly bedrock with some silt.	

*Bottom compositions are estimates based on field observations.

Table 11
Benthos Data Summary
Thompson Treatment Plant

Station Number	Sampling Dates	No. of Samples	Type of Samples	Total No. of Organisms	No. of Taxa Collected	Diversity Index	% of Class I	% of Class II	% of Class III
B-7	5/17	1	S*	302	18	2.98	56	19	25
	5/17 to 6/16	1	D**	47	4	0.78	2	2	96
	5/17 to 6/16	1	D	38	2	0.27	0	3	97
	6/16 to 7/24	1	D	33	4	0.86	3	9	88
	6/16 to 7/24	1	D	38	4	0.82	3	50	47
	7/24 to 8/21	1	D	18	1	∅	0	0	100
	7/24 to 8/21	1	D	32	3	0.58	3	3	94
[illegible]	5/17	1	S	95	12	2.42	14	34	52
	5/17 to 6/16	1	D	99	6	1.08	6	4	90
	5/17 to 6/16	1	D	37	3	0.55	3	0	97
	6/16 to 7/24	1	D	11	1	∅	0	0	100
	7/24 to 8/21	1	D	8	3	0i97	0	25	75
B-9	5/17	1	S	210	12	2.06	28	24	48
	5/17 to 6/16	1	D	41	5	1.08	2	10	88
	5/17 to 6/16	1	D	28	5	1.20	7	4	89
	6/16 to 7/24	1	D	28	1	∅	0	0	100
	6/16 to 7/24	1	D	32	1	∅	0	0	100
	7/24 to 8/21	1	D	13	1	∅	0	0	100
	7/24 to 8/21	1	D	81	5	0.91	1	5	94

* Surber Samples
** Artificial Substrate Samples

Table 12
Benthos Data
Thompson Treatment Plant

Class I	B-7a	B-7b	B-7b	B-7c	B-7c	B-7d	B-7d	B-8a	B-8b	B-8b	B-8c	B-8d	B-9a	B-9b	B-9b	B-9c	B-9c	B-9d	B-9d
Caddisflies																			
Hydroptilidae	65							1					53						
Philopotamidae	26												1						
Stoneflies																			
Perlidae	27	1											5						
Perlodidae	3																		
Crustaceans																			
Astacidae								2	1	1				1	1				
Isopoda	42							2											
Flatworms																			
Turbellaria	3						1	4	5										
ingernail Clams																			
Sphaeriidae	1				1			3											
Crane Flies																			
Tipuliidae	1												1						
Coelenterata																			
Hydridae		-*							-	-					-				
Leeches																			
Hirudinea				1				1							1				1
Class II																			
Caddisflies																			
Hydropsychidae	9		1					8					19	2					1
Stoneflies																			
Nemouridae	2												2						

*The number of these organisms were not counted.